Contactless Fingerprint Authentication

1. Overview

Aadhaar authentication today relies on fingerprint, iris, and face modalities. While face authentication has achieved widespread adoption due to its hygienic, contactless nature, contact-based fingerprint authentication still poses a few challenges, such as:

- Hygiene concerns in shared devices.
- Limited availability of certified fingerprint scanners.
- Hardware dependency in rural and mobile use-cases.

Contactless fingerprint authentication, leveraging standard mobile cameras and AI-driven enhancement, offers a hygienic and scalable alternative. It can enable touch-free capture, improve user convenience, and extend Aadhaar's reach to rural and mobile contexts with minimal infrastructure dependency.

2. Objectives

I. To design and develop an AI/ML-driven SDK for contactless fingerprint capture and authentication, ensuring high image quality, liveness, and spoof resistance.

II. To ensure compatibility with Aadhaar's AFIS (Automated Fingerprint Identification System), delivering ISO/IEC 19794-4 compliant templates from contactless captures.

III. To support seamless mobile-based deployments with lightweight, low-latency models, and to deliver SDKs suitable for authentication.

IV. To build a demo application showcasing real-time authentication using the SDK on mobile devices.

V. To develop a desktop-based QC/Test application for systematic evaluation of capture quality, liveness detection, and readiness scoring, including comparison between contactless and contact-based fingerprint captures.

3. Challenge Description

UIDAI invites proposals to develop SDK for contactless fingerprint authentication that:

a. Capture high-quality fingerprint images via smartphone RGB cameras or low-cost imaging devices, with auto-capture pipeline and real-time user guidance.
b. Implement preprocessing and auto-quality controls, including blur detection, brightness and glare management, ROI and finger alignment checks, and background interference correction.
c. Provide liveness and spoof detection against common attacks (printed photos, replay videos, silicone molds, 3D replicas).
d. Convert processed images into standardized fingerprint templates interoperable with UIDAI's AFIS.
e. Support real-time edge execution on Android devices with lightweight models, ensuring low-latency processing.
f. Provide both auto-capture (real-time guidance and automated capture) and manual capture (with quality validation).
g. Include a demo mobile app for finger print enrolment and authentication on-device using the SDK.
h. Include a QC/Test tool (desktop-based) to evaluate and benchmark contactless captures against contact-based fingerprint quality.

4. Solution Design Considerations

a) Capture & Preprocessing (AI/ML driven, real-time)

- Blur Detection: Lightweight model in the auto-capture pipeline to ensure sharp images only.
- Brightness & Glare Control: Real-time scoring models to detect overexposure, underexposure, and glare spots; provide user guidance for correction.
- Finger Positioning (ROI Evaluation): Detect if the finger is correctly positioned inside overlay with proper scale/alignment; prevent incomplete ROI or ridge loss.

- Background Interference Handling: AI module to isolate the finger from background clutter or skin-colored surroundings.
- Liveness Detection: Detects whether the fingerprint comes from a live human finger.
- Spoof Detection: Rejection of fake fingerprints (printed, replayed, silicone, or 3D).

b) SDK Requirements

- Lightweight & Efficient: Optimized to run on diverse Android devices with limited resources.
- Modes of Capture:
    - Auto-Capture: Real-time capture pipeline with guidance and automated trigger.
    - Manual Capture: User-triggered capture with automated quality guidance.

c) Applications to be Delivered

1. Demo Mobile App: Integrating the SDK, performing enrolment and authentication on-device.
2. Test/QC Application (Desktop):
    - Image Quality Assessment: Metrics for blur, brightness, glare, ROI, background, and preprocessing pipeline performance.
    - Readiness Scoring: Quantify template quality (minutiae count, clarity), flagging acceptable vs. rejected images for matching.
    - Comparison Tool: Evaluate contactless fingerprint captures against contact-based captures for quality benchmarking.

d) Performance & Operational Targets

- Latency: ≤2 seconds per capture on Android devices with version 9 and above.
- Template Compliance: ISO/IEC 19794-4 standard templates, compatible with UIDAI AFIS.

- Compatibility: With all iOS and Android based mobiles which are supported by the Aadhaar Mobile Application.
- Inclusivity: Robust across diverse demographics, skin tones, ages, and worn fingerprints.

4.1 Key Results

- SDK (Android & iOS + desktop integration) for contactless fingerprint capture, quality assurance, and liveness/spoof detection.
- Demo app showcasing real-time authentication on low & high-end mobile device.
- QC/Test application benchmarking capture quality, readiness scoring, and contactless vs. contact-based performance.
- End-to-end reports validating accuracy, usability, and AFIS interoperability on low & high-end mobile devices.

5. Evaluation Criteria

a. Accuracy — Matching FAR/FRR comparable to certified contact-based fingerprint devices.
b. Quality Assurance — Effectiveness of blur detection, glare/brightness management, ROI handling, and readiness scoring.
c. Liveness & Spoof Resistance — Robust detection of fake fingerprints across multiple attack vectors.
d. Integration Readiness — Compatibility with UIDAI AFIS and mobile authentication APIs.
e. User Experience — Demonstrated hygiene benefits, usability in rural/urban deployments, and real-time capture guidance.
f. Performance — Latency, memory footprint, and efficiency on Android/iOS and desktop platforms(QC Tool).

g. Standards Compliance — Adherence to ISO/IEC 19794-4 and UIDAI certification standards.
h. Innovation — Advanced AI/ML techniques for auto & manual-capture, real-time guidance, and template quality improvement.